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PANDION LOVENSIS, A NEW SPECIES OF OSPREY FROM THE LATE MIOCENE OF FLORIDA

Jonathan J. Becker

Abstract.—*Pandion lovensis* n. sp. (Aves: Pandionidae) is described from the late Miocene (latest Clarendonian) of Florida. This species, based on pelvic limb elements, appears to be the most primitive member of the genus.

The modern osprey (*Pandion haliaetus*) is the sole living representative of an enigmatic family of diurnal raptors. A number of detailed studies have investigated the morphology of the osprey in order to clarify its taxonomic position (Compton 1938; Hudson 1948; Sibley and Ahlquist 1972; Jollie 1976–1977). These studies have placed the osprey in a separate family or suborder, usually allied with the hawks and eagles.

Warter (1976) discussed the fossil record of the Pandionidae and described the first paleospecies, *Pandion homalopteron,* from Sharkstooth Hill, but did not find any convincing evidence to ally the modern osprey closely with any other falconiform group. Sharkstooth Hill near Bakersfield, Kern County, California, is early middle Miocene (about 14.5–13 million years B.P.) and is "closely tied into the late 'Temblor' megainvertebrate stage and the Luisian microinvertebrate stage" (Repenning and Tedford 1977:79). *Pandion homalopteron,* based on associated humeri and ulnae, represents an osprey slightly larger than the average modern osprey, that shows evidence of weaker wing musculature (Warter 1976).

Brunet (1970) proposed the transfer of *Palaeocircus cuvieri* Milne-Edwards from the Accipitridae to the Pandionidae, but because of the incompleteness of the holotype, a fragmentary carpometacarpus, this has not been accepted by other workers (Warter 1976).

Reported here, from the late Miocene of Florida is the second known paleospecies of osprey.

Abbreviations.—Specimens cited below are housed in the following institutions: Florida State Museum (UF), collection of Pierce Brodkorb (PB), and Natural History Museum of Los Angeles County (LACM).

Recent specimens examined.—*Pandion haliaetus carolinensis* four male specimens, PB 20312, PB 39212, PB 27958, UF 19406; four female specimens, PB 17061, UF 14546, UF 17082, UF 18215; four specimens of unknown sex, PB 34670, PB 39613, PB 37976, PB 34669.

Fossil specimens examined.—Referred proximal end of left tibiotarsus of *Pandion homalopteron* (LACM 42815). Subsequent to Warter's (1976) description of this species, this tibiotarsus was collected by Mr. William Hawes from the same location at Sharkstooth Hill (LACM locality 3205) that he collected the type-material of *P. homalopteron* (L. G. Barnes, in litt. 1982). It should be noted, that although this specimen bears the same catalog number as the holotype, it cannot be considered type-material (except as a referred hypotype), as it was not included in the original description.

Descriptive statistics are based on all above recent specimens. Morphological comparisons are based on the seven specimens in the Brodkorb collection. Measurements (Table 1) were made with Kanon dial calipers, accurate to 0.05 mm and rounded to the nearest 0.1 mm. BMDP Statistical Software program BMDPlD was used to calculate simple descriptive statistics (Dixon 1981). Computations were made at the Northeast Regional Data Center (NERDC) at the University of Florida, Gainesville. All fossil specimens are deposited in the Vertebrate Paleontology collections of the Florida State Museum, University of Florida (UF). Anatomical terminology follows Baumel et al. (1979) and Howard (1929).

Order Accipitriformes (Falconiformes auct.)
Family Pandionidae (Sclater and Salvin, 1893)

Skeletal elements of pelvic limb distinguished from other accipitriform families by the following combination of characters: (1) femur with very deep popliteal fossa; (2) tibiotarsus with extensor canal very deep under tendinal bridge with single distal opening; (3) fibula fused far distad; (4) tarsometatarsus relatively short, with ossified retinaculi extensoris for M. extensor digitorum longus; (5) hypotarsus extremely large with a single circular opening for tendons of Mm. flexor digitorum longus and flexor hallucis longus; (6) calcaneal ridge grooved; (7) trochleae strongly arched; (8) claws rounded beneath.

Genus *Pandion* Savigny, 1809
Pandion lovensis, new species
Figs. 1, 2

Holotype.—Nearly complete left tarsometatarsus. Vertebrate Paleontology collections of the Florida State Museum, UF 25950 (Fig. 1b, c); collected in 1979 by personnel of the Florida State Museum.

Type-Locality.—Love Bone Bed local fauna. Florida, Alachua County, along State Road 241, NW ¼, SW ¼, NW ¼, Sec. 9, T. 11 S., R. 18 E., Archer Quadrangle, U.S. Geological Survey 7.5 minute series topographical map, 1969. Webb et al. (1981) give an overview of this local fauna.

Horizon.—Late Miocene, latest Clarendonian land mammal age (approximately 9 million years B.P.). The Love Bone Bed local fauna originates from fluvial sediments of the Alachua Formation (Williams et al. 1977).

Etymology.—For the type locality, the Love Bone Bed.

Paratypes.—Distal half of right femur, UF 25766; distal end of right tibiotarsus, UF 25884; complete left tibiotarsus, UF 25928; right tarsometatarsus lacking proximal end, UF 25863; ungual phalanges, UF 26055, UF 26056, UF 29660.

Measurements.—Table 1.

Diagnosis.—Distinguished from *P. haliaetus* by: longer and more slender tarsometatarsus, lateral proximal vascular foramen opening within hypotarsal canal; femur with patellar sulcus broader and caudal intermuscular line more mediad; tibiotarsus with anterior and posterior intercondylar sulci wider and less deep, cranial opening of extensor canal larger and more transversely oriented, and distal end wider. Distinguished from *P. homalopteron* by a tibiotarsus with smaller transverse width of proximal end and deeper fossa retrocristalis.

Table 1.—Measurements of *Pandion* spp. Data are number of specimens (n), mean ± standard deviation ($\bar{x}$ ± SD) and range. Tibiotarsus—A, Total length; B, Length fibular crest; C, Least depth shaft; D, Depth proximal end; E, Transverse width proximal end; F, Transverse width distal end, across anterior portion of condyles; G, Transverse width distal end, across posterior portion of condyles; H, Depth medial condyle; I, Depth lateral condyle; J, Least depth intercondylar area. Tarsometatarsus—K, Total length, from eminentia intercondylaris through trochlea III; L, Length metatarsal I facet; M, Transverse width trochlea III; N, Transverse width distal end; O, Depth trochlea III; P, Transverse width proximal end; Q, Depth proximal end, excluding hypotarsus. Femur—R, Transverse width of lateral condyle; S, Transverse width of medial and lateral condyles; T, Transverse width lateral condyle and trochlea fibularis; U, Transverse width distal end; V, Depth distal end; W, Depth femoral shaft cranial to condyles.

Measurement	*P. h. carolinensis*			*P. homalopteron*	*P. lovensis*
	$\bar{x}$ ± SD	(n)	Range	X_i	X_i
Tibiotarsus:					
A	123.59 ± 4.62	(12)	119.2–130.8	—	124.8
B	34.82 ± 2.09	(13)	31.2–38.2	—	32.7
C	5.59 ± 0.29	(12)	5.2–6.1	—	5.5; 5.7
D	17.00 ± 0.92	(13)	15.9–18.5	17.4	17.0
E	13.17 ± 0.60	(13)	12.3–14.0	14.3	13.1
F	14.08 ± 0.69	(12)	13.1–15.1	—	14.9; 15.0
G	10.36 ± 0.50	(12)	9.6–11.1	—	12.0; 12.1
H	13.18 ± 0.68	(12)	12.4–14.2	—	13.2; 13.3
I	12.77 ± 0.57	(12)	12.0–13.6	—	12.0; 12.5
J	5.83 ± 0.29	(12)	5.4–6.5	—	6.6; 6.6
Tarsometatarsus:					
K	51.86 ± 1.64	(12)	49.7–54.9	—	59.5
L	9.38 ± 0.80	(12)	8.0–10.6	—	8.0; 8.4
M	6.80 ± 0.56	(12)	5.8–7.6	—	7.8; 7.8
N	15.00 ± 0.54	(12)	14.4–15.9	—	16.4
O	4.98 ± 0.26	(12)	4.6–5.5	—	5.7; 5.7
P	14.46 ± 0.76	(12)	13.4–15.7	—	14.7
Q	5.49 ± 0.28	(12)	5.1–6.0	—	6.7
Femur:					
R	3.12 ± 0.27	(13)	2.8–3.6	—	3.1
S	12.14 ± 0.69	(13)	11.2–12.9	—	12.4
T	6.81 ± 0.56	(13)	6.0–7.9	—	6.6
U	15.29 ± 0.89	(13)	14.0–16.6	—	15.2
V	13.51 ± 0.47	(13)	12.7–14.2	—	12.8
W	7.70 ± 0.35	(13)	7.2–8.3	—	7.2

Comparisons and description.—Unless otherwise stated, all comparisons are made in relation to 7 specimens (Pierce Brodkorb collection) of *Pandion haliaetus carolinensis* Gmelin, 1788.

Femur.—*Pandion lovensis* n. sp. has caudal intermuscular line more mediad, merging smoothly with the crista supracondylaris medialis, forming a sharp caudomedial border immediately above the medial epicondyle. Caudal aspect of the medial condyle broader. Popliteal fossa slightly broader. Caudal aspect of lateral condyle (i.e., tibial articular surface) extending less craniad and is not inclined laterad. Crista tibiofibularis and lateral epicondyle less pronounced. Patellar sulcus slightly broader.

Tibiotarsus.—Fibular crest shorter. Both anterior and posterior intercondylar

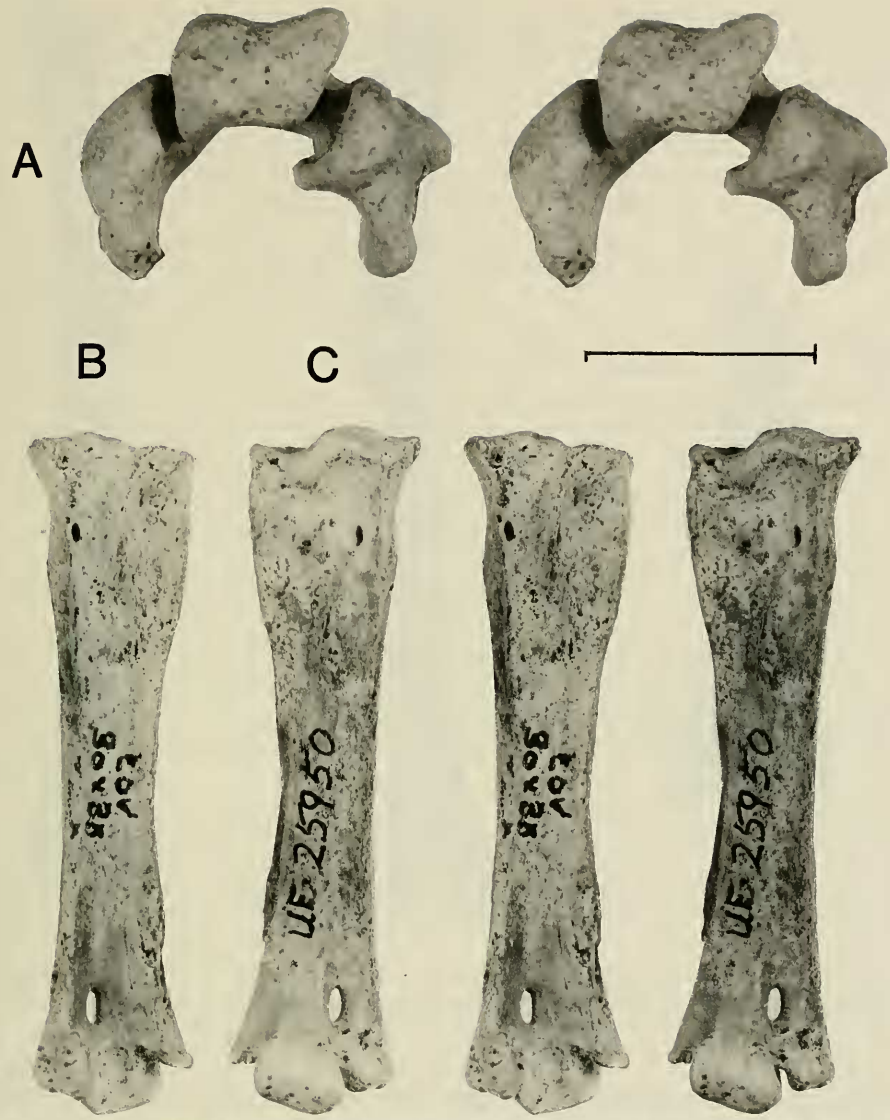

Fig. 1. Stereophotographs of tarsometatarsi of *Pandion lovensis* n. sp. A, Paratype UF 25863, distal view. B, C. Holotype, UF 25950. B, Caudal view; C, Cranial view. Scale equals 10 mm. (A); 20 mm. (B, C).

sulci wider and less deep. Both lateral and medial epicondylar depressions deeper and more distinct. Cranial opening of extensor canal larger and more transversely oriented. Internal ligamental prominence more distinct. Distal end wider, especially caudal portion.

The referred proximal end of tibiotarsus of *Pandion homalopteron* (LACM 42815), when compared with *P. haliaetus,* is robust, with a greater transverse width of proximal end. Crista cnemalis lateralis slightly elongated, producing a more pronounced incisura tibialis and a broader sulcus intercristalis. Facies gas-

Fig. 2. Paratypes of *Pandion lovensis*. A, Caudal view femur UF 25766; B, Cranial view tibiotarsus UF 25928; C, Caudal view tibiotarsus UF 25928. Scales = 10 mm.

trocnemalis flatter. Distinct notch present on caudo-lateral margin of proximal articulating surface. Slight ridge extends proximad from tuberositas poplitea.

In comparison with *Pandion homalopteron, P. lovensis* has a smaller transverse width, a less distinct notch on the caudo-lateral margin of the proximal end, and a distinctly deeper fossa retrocristalis.

Tarsometatarus.—Shaft longer, more slender, and less flattened dorso-plantarly. Fossa parahypotarsalis medialis slightly more excavated. Crista medialis hypotarsi extends a proportionally shorter distance down shaft. Lateral foramen vascularia proximalia opens within hypotarsal canal (outside in all specimens of *Pandion haliaetus* examined). Fovea ligamentum collateralis on trochlea IV larger and deeper. Trochlea IV less recurved, anterior surface flattened. Trochlea III larger. Medial foramen vascularia proximalia proximal to origin of inner strut of arcus extensoris. Fossa infracotylaris dorsalis deeper. Medial border of trochlea III projects laterad (dorsad in *P. haliaetus*). Distal end larger. In medial view, caudal process on trochlea II proportionally longer.

Discussion.—The power-arm ratio of the tarsometatarsus has been the focus of many investigations (Miller 1911, 1912; Howard 1932; Jollie 1976–1977; among others). The major flexor of the tarsometatarsus on the shank is the M. tibialis anterior (=M. tibialis cranialis of Baumel et al. 1979) and, to a lesser degree, the M. extensor digitorum longus. In *Pandion haliaetus,* the tibialis anterior arises by two heads, a tibial head on the anterior side of the tibial crest, extending in a narrow line down the medial side of the tibial shaft; and a femoral head extending from the distal apex of the external condyle of the femur. This muscle inserts by a single tendon on the tibialis anterior tuberosity on the proximal end of the tarsometatarsus (Hudson 1937, 1948).

The power-arm ratio (Miller 1912, 1925) is calculated by dividing the length from the proximal end to the midpoint of the tibialis anterior tubercle (=power-arm) multiplied by 100, by the total length of the tarsometatarsus (=resistance or weight-arm). Miller (cited in Jollie 1976–1977) noted that species with long tarsi have a short power-arm ratio while those species with a short broad tarsus have a relatively large ratio. Miller (1911), Howard (1932), and Jollie (1976–1977) provide tables of power-arm ratios for comparison. It is interesting to note that the modern osprey has the greatest power-arm ratio (32.2%) of any accipitriform species. *Pandion lovensis* has a much smaller power-arm ratio (17.0 mm/59.5 mm × 100 = 28.6%). This is approximately 11% less than the modern osprey. An increase in length of the tarsometatarsus, without a concomitant shift in the position of the tibialis anterior tubercle is responsible for the decrease in the power-arm ratio in *P. lovensis.* The increase in length would also allow the distal end of the tarsometatarsus to be moved at a faster rate, all other things being equal.

The interpretation of these differences is difficult. Fisher (1945:742) states "The development of this great flexor of the tarsus may be correlated with ability to walk or run, ability to grasp with the foot as in perching or in predation, and with weight of the foot or of the entire body. In fact it is impossible to define and distinguish individual adaptations."

Because *P. homalopteron, P. lovensis,* and *P. haliaetus* have only one known skeletal element in common, any proposed phylogeny is tenuous. *Pandion homalopteron* is not very distinct in wing morphology from the modern osprey, even though a large interval of time separates them (Warter 1976). The only known hindlimb element of this species, a proximal end of a tibiotarsus, also appears close to that of the modern osprey. *Pandion lovensis* is less derived than either of these species and shares a number of characters with the Accipitridae, the proposed sister taxa of the Pandionidae (Jollie 1976–1977). These characters include a femur with a broader and less deep patellar sulcus, and the caudal intermuscular line medial; a tibiotarsus with broader intercondylar sulci; and a tarsometatarsus which is longer and less broad, with a reduced power-arm ratio.

Pandion lovensis appears to be the least derived member of the genus and represents a lineage distinct from that of *P. homalopteran* and *P. haliaetus.*

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Department of Zoology, University of Florida, Gainesville, Florida 32611.